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Variations in Treatment and Costs for Distal Radius Fractures in Patients Over 55 Years of Age: A Population-Based Study

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Abstract

Objective To evaluate the rate of surgery for symptomatic malunion after non-operatively treated distal radius fractures in patients aged 55 and above, and to secondarily report differences in demographics, geographical variation, and utilization costs of patients requiring subsequent malunion correction.

Methods We identified patients aged 55 and above who underwent nonoperative treatment for a distal radius fracture between 2007 and 2016 using the IBM MarketScan database. In the nonoperative cohort, we identified patients who underwent malunion correction between 3 months and 1 year after distal radius fracture. The primary outcome was rate of malunion correction. Multivariable logistic regression controlling for sex, region, and Elixhauser Comorbidity Index (ECI) was used. We also report patient demographics, geographical variation, and utilization cost.

Results The rate of subsequent malunion surgery after nonoperative treatment was 0.58%. The cohort undergoing malunion surgery was younger and had a lower ECI. For every 1-year increase in age, there was a 6.4% decrease in odds of undergoing surgery for malunion, controlling for sex, region, and ECI (odds ratio = 0.94 [0.93–0.95]; $p < 0.01$). The southern United States had the highest percentage of patients initially managed operatively (30.7%), the Northeast had the lowest (22.0%). Patients who required a malunion procedure incurred higher costs compared with patients who did not ($7,272 ± 8,090 vs. $2,209 ± 5,940; $p < 0.01$).

Conclusion The rate of surgery for symptomatic malunion after initial nonoperative treatment for distal radius fractures in patients aged 55 and above is low. As younger and healthier patients are more likely to undergo malunion correction with higher associated costs, surgeons may consider offering this cohort surgical treatment initially.

Keywords
- distal radius fracture
- elderly
- malunion
- nonoperative
- variation

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Introduction

Distal radius fractures are one of the most commonly treated fractures in the United States.[1,2] The incidence of distal radius fractures continues to increase as a result of an active and aging population.[3,4] Multiple treatment options exist, with the two most common being nonoperative treatment consisting of immobilization (with or without a preceding closed reduction) and open reduction with internal fixation (ORIF).[5] While early data supported ORIF, multiple well-conducted studies have demonstrated comparable outcomes between nonoperative and operative fixation in “older” adults.[6–8] To this effect, the American Academy of Orthopaedic Surgeons (AAOS) clinical practice guidelines (CPG) provide a strong recommendation that operative treatment for “geriatric” patients does not lead to improved long-term patient-reported outcomes as compared with nonoperative treatment.[9]

CPG are statements and recommendations informed by evidence that are intended to optimize patient care based upon a thorough and unbiased assessment of the benefits and risks of treatment options. These guidelines and recommendations, along with evidence, are meant to guide treatment and can be used within a shared decision-making approach. Shared decision-making is the process by which the physician seeks the patient’s participation, evidence-based treatment options are explored and discussed, the patient’s preferences and values are accounted for, and a patient’s decision is evaluated within the context of their values.[10–12] Evidence not only shows that patients prefer taking an active role in their decision-making process but also that it can improve patient confidence, compliance, participation, and satisfaction with their care.[13–17] Additionally, patient preferences for treatment options for distal radius fractures vary[10] and are often not accounted for without shared decision-making. These evidence-based results and CPG can serve as guiding principles for use alongside shared decision-making models.

While several studies note high (frequently 100%) malunion rates and low complication rates (e.g., symptomatic malunion) with nonoperative treatment of distal radius fractures in “older” patients,[6–8] it is possible these studies may fail to capture complications that occur at a time distant from the index treatment decision.[18] For example, Mulders et al, in a retrospective review of adults (mean age of 62 years) treated nonoperatively for distal radius fracture, demonstrate that 40% of patients underwent subsequent surgery due to secondary displacement or symptomatic malunion.[18] Additionally, the results of prior efficacy trials that use age as a proxy for function may not inform care for patients who have personalized goals or functional demands that are discrepant from what may be expected based on age alone. As such, we sought to understand the natural history of nonoperatively treated distal radius fractures outside of a controlled study environment (e.g., what is occurring in routine clinical care). The purpose of this study was to evaluate the rate of malunion correction after nonoperatively treated distal radius fractures in patients aged 55 and older (the CPG age at time of analysis). We secondarily report differences in demographics, geographical variation, and cost of those requiring subsequent malunion correction.

Materials and Methods

Database

We conducted a retrospective cohort study using the IBM MarketScan Commercial Claims and Encounters and Medicare Supplemental and Coordination of Benefits databases (MarketScan, IBM Watson Health). MarketScan is a commercially available national insurance claims database. All data are deidentified and thus exempt from institutional review board approval. The MarketScan database contains patient-level health insurance claims data across the continuum of care (e.g., inpatient, outpatient, outpatient pharmacy) as well as enrollment data from large employers and health plans across the United States who provide private health care coverage for more than 150 million employees, their spouses, and dependents. This database includes a variety of fee-for-service, preferred provider organizations, and capitated health plans. The MarketScan database includes patients covered between January 1, 2007 through December 31, 2016.

Study Cohorts

We identified all patients who had a record of distal radius fracture (intra- and extra-articular) denoted by International Classification of Diseases, Ninth Revision (ICD-9) and International Classification of Diseases, Tenth Revision (ICD-10) diagnosis codes (►**Supplementary Table S1**). We used an age cutoff of 55 as it was used in the AAOS CPG at the time of analysis and writing to define “geriatric” patients and as a range of ages have been used as the inclusion criteria when studying the treatment of displaced distal radius fractures.[6,7,19–21] Within this population, only patients aged 55 years and older that were continuously enrolled for at least 1 year before and after their initial distal radius fracture were included for analysis. Patients with a Current Procedural Terminology (CPT) code denoting surgical intervention, including ORIF, external fixation, or percutaneous pinning (►**Supplementary Table S1**), within 14 days of initial fracture comprised the operative cohort, and those without record of surgical fixation were included in the nonoperative cohort.

Within the nonoperative cohort, we created a subcohort of patients who underwent surgical intervention for distal radius malunion as defined using CPT codes for malunion correction, ulnar shortening osteotomy, wrist arthroscopy, or Darrach procedure (►**Supplementary Table S1**) between 3 months and 1 year after initial fracture. We report the rate of distal radius fractures initially treated nonoperatively that subsequently underwent surgery with the above CPT codes. For all cohorts, age at date of index fracture, sex, region, and core-based statistical area (CBSA) were collected. A CBSA consists of a U.S. urban center and adjacent counties with socioeconomic ties to that urban center. The number of included patients per CBSA was tabulated. For the top 100

CBSAs with included patients (all with > 200 patients), the percentage of patients undergoing operative treatment was recorded. Elixhauser Comorbidity Index (ECI) was calculated for each patient using ICD codes based on the methodology of van Walraven et al.[22] The costs of all claims associated with distal radius fracture were tracked for a 1-year period following the index diagnosis for the operative and nonoperative cohorts.

Statistical Analysis

Categorical data were reported as frequencies and percentages, and continuous data were reported as mean ± standard deviation. Chi-square tests were used to compare categorical variables. Student's *t*-tests were used to compare continuous variables. Multivariable logistic regression models controlling for sex, region, and ECI were used to evaluate the effect of age on malunion surgery for the nonoperative cohort. A *p*-value of 0.05 was set as significant.

Results

A total of 123,885 patients aged 55 and older with distal radius fractures met the inclusion criteria and were included in the analysis. Demographic data are presented in ►**Table 1**. There were more female patients compared with male patients (80.7% vs. 19.3%; $p < 0.01$). Of those included, 33,874 (27.3%) patients comprised the initially operative cohort, and 90,011 (72.7%) made up the initially nonoperative cohort (►**Table 1**). Patients in the initially nonoperative cohort were older (69.5 ± 11.4 vs. 66.1 ± 9.7 years; $p < 0.01$) and had higher ECI scores (4.7 ± 7.3 vs. 3.5 ± 6.2; $p < 0.01$) compared with the initially operative cohort.

Within the initially nonoperative cohort, 0.58% of patients underwent surgery for malunion within 1 year of index fracture (►**Fig. 1**). Of these patients, the majority (68.7%) was younger than 65 years old (►**Table 2**). Further, in the initial nonoperative cohort, patients undergoing malunion procedures had lower ECI scores compared with patients who did not proceed with surgery for malunion (3.6 ± 6.9 vs. 4.7 ± 7.3; $p < 0.01$). In patients initially treated nonoperatively, for every 1-year increase in age there was a 6.4% decrease in odds of undergoing surgery for malunion, after controlling for ECI, region, and sex (odds ratio = 0.94 [0.93–0.95]; $p < 0.01$). The mean time to malunion correction was 197 ± 75 days. Procedure-specific data are presented in ►**Table 2**.

Out of the 123,885 patients included, 83% had record associated with a CBSA. A map of the top 100 CBSAs and percentage of patients initially treated operatively are displayed in ►**Fig. 2**. Of these CBSAs, the areas with the 10 highest and 10 lowest percentage of patients managed operatively are presented in ►**Fig. 3**. The southern U.S. was the region with the highest percentage of patients initially managed operatively (30.7%) followed by the North-Central region (27.6%), the West (26.3%), and the Northeast (22.0%).

Total 1-year costs associated with distal radius fracture were higher for the operative cohort compared with the nonoperative cohort ($3,410 ± 4,473 vs. $2,210 ± 5,917; $p < 0.01$). Within the nonoperative cohort, patients that went on to have a malunion procedure incurred higher costs compared with those that did not undergo subsequent

Table 1 Demographic data of patients who received operative and nonoperative treatment after distal radius fracture

	Operative cohort ($n = 33,874$)	Nonoperative cohort ($n = 90,011$)		
		All ($n = 90,011$)	No subsequent surgery ($n = 89,490$)	Malunion correction ($n = 521$)
	N (%)	*N* (%)	*N* (%)	*N* (%)
Age group (y)				
55–64	19,738 (58.3)	41,579 (46.2)	41,221 (47.1)	358 (68.7)
65–74	6,648 (19.6)	16,803 (18.7)	16,710 (18.7)	93 (17.9)
75+	7,488 (22.1)	31,629 (35.1)	31,559 (35.3)	70 (13.4)
Region				
Northeast	5,293 (15.6)	18,799 (20.9)	18,712 (20.9)	87 (16.7)
North Central	10,034 (29.6)	26,316 (29.2)	26,172 (29.2)	144 (27.6)
South	12,490 (36.9)	28,221 (31.4)	28,039 (31.3)	182 (34.9)
West	5,475 (16.2)	15,310 (17.0)	15,209 (17.0)	101 (19.4)
Sex				
Male	5,811 (17.2)	18,141 (20.2)	18,042 (20.2)	99 (19.0)
Female	28,063 (82.8)	71,870 (79.8)	71,448 (79.8)	422 (81.0)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Age (y)	66.1 (9.7)	69.5 (11.4)	69.5 (11.4)	63.4 (8.2)
ECI	3.5 (6.2)	4.7 (7.3)	4.7 (7.3)	3.6 (6.9)

Abbreviations: ECI, Elixhauser Comorbidity Index; SD, standard deviation.

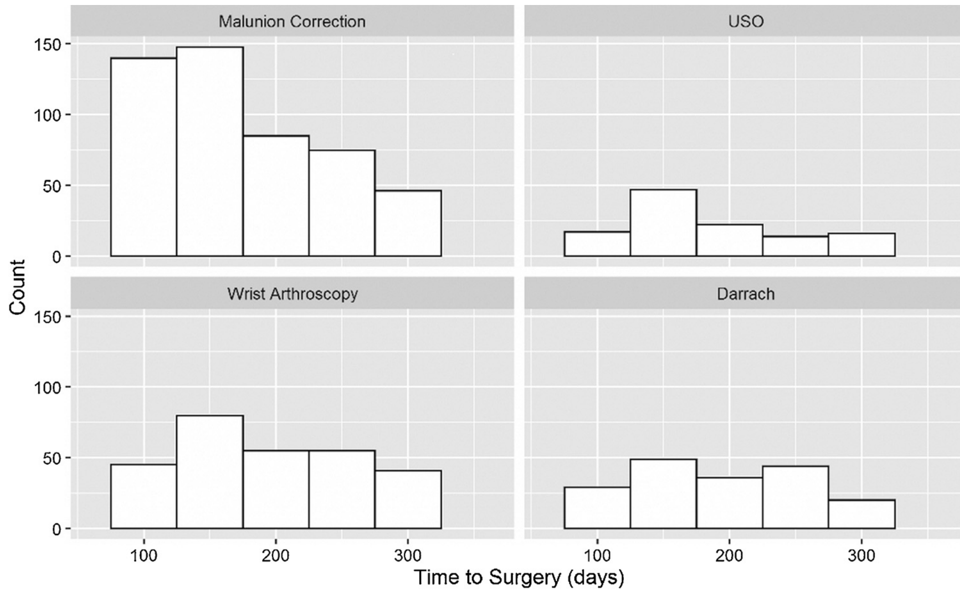

Fig. 1 Histograms for time to each procedure for patients who were initially treated nonoperatively but required subsequent malunion procedures within 1 year of index fracture. (Bars containing fewer than 11 participants were removed to ensure patient privacy.)

Table 2 Malunion correction procedures for patients initially treated nonoperatively

	All reoperation procedures ($n = 521$)	Malunion procedure ($n = 274$; 52.6%)	USO ($n = 67$; 12.9%)	Wrist arthroscopy ($n = 150$; 28.8%)	Darrach ($n = 104$; 20.0%)
Age, mean (SD)	63.4 (8.2)	64.1 (8.2)	61.4 (6.6)	60.8 (5.4)	68.8 (9.3)
Male, *n* (%)	99 (19.0)	50 (18.2)	12 (17.9)	35 (23.3)	15 (14.4)
Female, *n* (%)	422 (81.0)	224 (81.8)	55 (82.1)	115 (76.7)	89 (85.6)
Time to procedure days (mean, SD)	197 (75)	186.4 (75.3)	199.6 (74.1)	213.1 (77.3)	198.4 (69.1)

Abbreviations: SD, standard deviation; USO, ulnar shortening osteotomy.
Note: Procedure percentages do not sum to 100% because some patients received > 1 type of procedure.

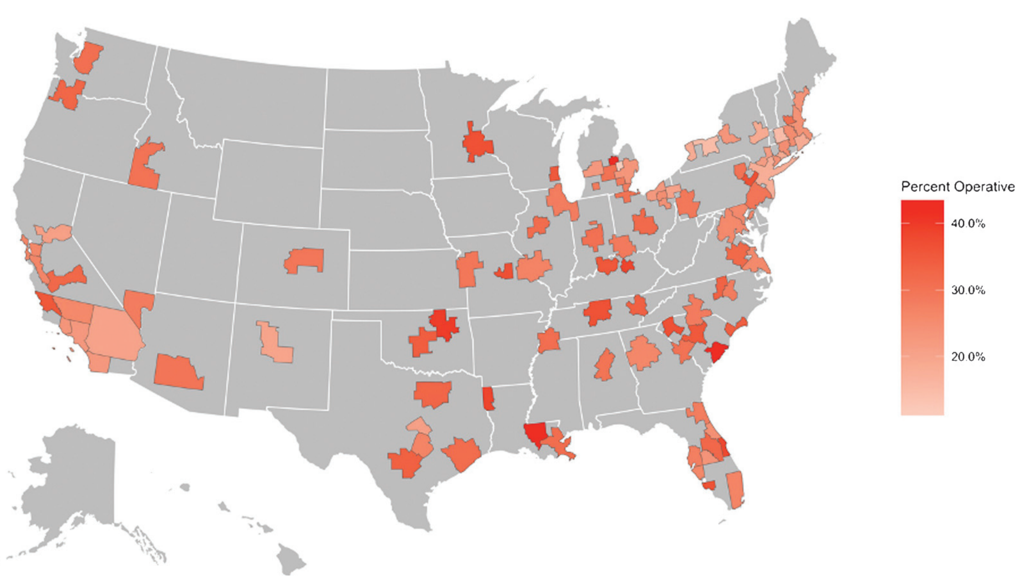

Fig. 2 Map of the United States containing the 100 top core-based statistical areas (CBSAs) with included patients, showing the percentage of patients who are initially managed operatively by CBSA.

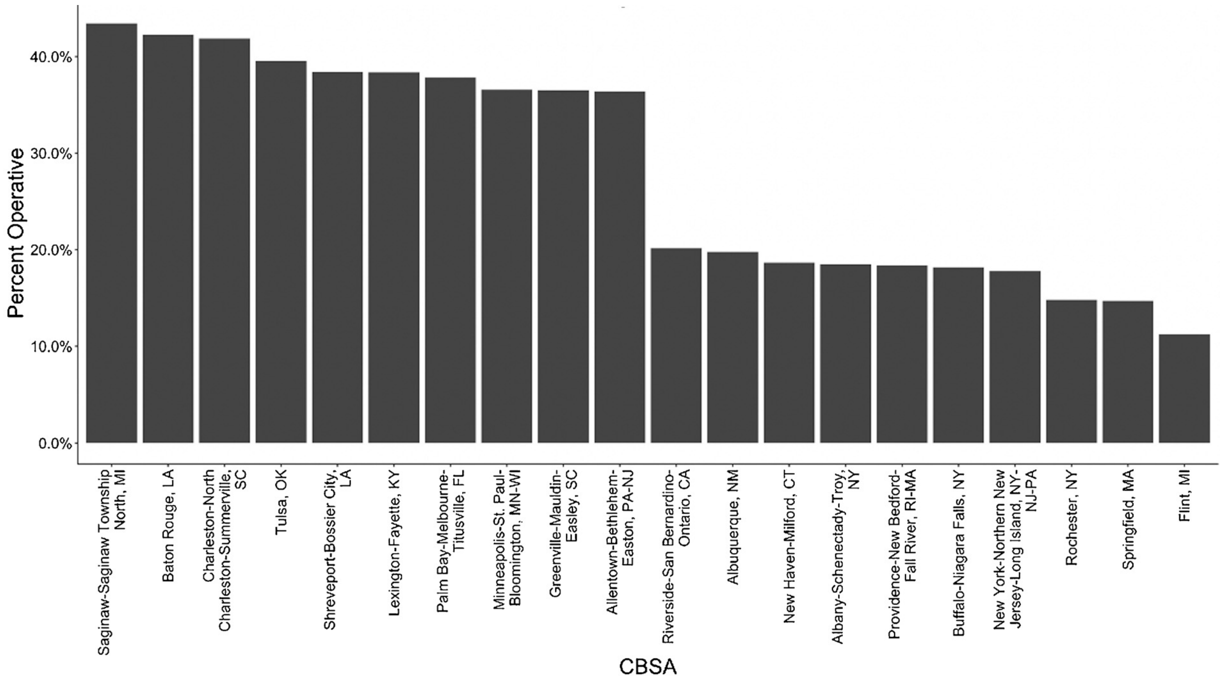

Fig. 3 The 20 CBSAs with the highest and lowest percentage of patients that are initially treated operatively.

malunion procedures ($7,272 ± 8,090 vs. $2,209 ± 5,940; $p < 0.01$). Furthermore, costs were significantly higher for patients that were initially managed nonoperatively but eventually required surgery for a malunion compared with patients who were initially treated with surgery ($7,272 ± 8,090 vs. $3,410 ± 4,473; $p < 0.01$).

Discussion

Multiple studies demonstrate high rates of asymptomatic malunion in "older" patients treated nonoperatively for distal radius fractures. In seeking to evaluate how these results extrapolate to practice patterns, we found similarly low rates of malunion correction. Our results demonstrate that while malunion correction is low, it occurs most frequently in younger patients with fewer comorbidities. While we do not believe this study will change practice, it does validate that what is substantiated in research settings, is similar to that of clinical practice. As such, our findings also support the updated AAOS CPG as the age criteria for "geriatric" has been iterated from greater than 55 to greater than 65 years of age (e.g., in this study, the majority of patients initially treated nonoperatively that underwent a malunion procedure were in the 55–65 cohort).

Our results demonstrate a 0.58% rate of malunion surgery within 1 year of diagnosis. This is substantially lower than that reported by DeGeorge et al.[23] While these authors reported a 19% rate of secondary procedures within 1 year of nonoperative treatment of distal radius fractures in patients 65 years or older, they do not report the rate of each secondary procedure or the indication (e.g., indications other than malunion). Mulders et al demonstrate a 40% rate of subsequent surgery due to secondary displacement or symptomatic malunion after initial nonoperative treatment.[18] These rates may vary, in part, due to study methodology and treatment protocols.

A driving force behind this investigation was to understand the natural history of nonoperatively treated distal radius fractures outside of a controlled study environment. For example, while protocolized and randomized controlled trials (RCTs) demonstrate low rates of symptomatic malunions requiring surgery, it is possible that these protocols make surgical treatment of malunion difficult during the study period. Bartl et al conducted a pragmatic randomized study of ORIF versus immobilization in patients 65 years or older, and while they found no differences in functional outcome scores, they noted that 41% of patients initially treated with immobilization had loss of reduction to the extent of requiring operative intervention.[6] The pragmatic study underscores that complications (e.g., loss of reduction) may occur, that, outside of a RCT with a specific protocol, may be treated in routine practice (e.g., loss of reduction in a RCT may be classified as such, but in routine practice this may be treated with surgical fixation or go on to asymptomatic malunion). Other examples are demonstrated in the literature.[24,25] Truntzer et al in reviewing complication rates after hip arthroscopy, reported higher complication rates using a national payer-based database than reported in the literature.[24] Desai et al in surveying authors to determine the nature and distribution of nerve injuries following elbow arthroscopy, concluded that the risk of such injuries is likely underreported in the literature.[25]

These results may also serve as information to guide treatment decisions and counsel patients. Understanding patients' preferences is important when applying CPG and evidence to clinical care. For example, a healthy 60-year-old patient being treated nonoperatively may want to understand that the risk of her desiring a surgical procedure for malunion may be higher than a patient who is older and less healthy. Shared decision-making approaches may better align initial treatment and minimize subsequent malunion surgery. Also of note, a majority of malunion correction procedures occur within the first 200 days, which has implications for patient counseling and timing of follow-up.

We found substantial variation in the distribution of treatment based on geographic location that likely demonstrate unwarranted variation in care, similar to prior reports.[26] In general, patients in the Northeast had the lowest rates of initial operative treatment while patients in the South were the most likely to undergo initial operative treatment. However, individual CBSAs within each region demonstrated varying rates of operative treatment. For example, 43.4% of patients in the Saginaw, Michigan (MI) CBSA received surgery compared with just 12.2% of patients 40 miles away in the Flint, MI CBSA, where patient populations are likely similar and unlikely to explain this difference. Our cost data show similar patterns to prior studies.[27] In addition to similar findings for higher costs related to operative treatment, the current investigation shows that in patients initially managed nonoperatively, those that require surgery for malunion incur significantly higher costs compared with patients that underwent initial operative management ($7,272 vs. $3,410).

The limitations of this study are inherent to national database registries, including reliance upon accurate coding and inability to control for coding practice variation.[28,29] It is possible that we did not fully capture the rate of malunion procedures as we only followed patients to 1 year postoperatively. However, to accurately record patients requires continuous enrollment (e.g., following patients out further than 1 year will substantially decrease the cohort of patients we can follow). This is mitigated in that a majority (54%) of procedures occurred by 6 months and 19% occurred in the last 3 months. To the counterpoint, it may take several months for a malunion to be diagnosed and subsequently treated. It is also possible that treatments we included were for a problem unrelated to a distal radius malunion. However, based on our relatively low rate of reoperation, it is unlikely we are capturing extra unrelated events. Also critical to note is that a surgical procedure for malunion correction may not fully identify all patients that have a symptomatic malunion (e.g., there may be patients with a symptomatic malunion that are limited by their malunion but not to the extent of desiring or being offered a surgical correction), which would underestimate the rate of symptomatic malunion. These patients may be treated with injections, occupational therapy, and/or anti-inflammatories and not captured by our symptomatic malunion cohort undergoing surgery. Given the methodology used (claims database), it was not feasible to control for or analyze patients by facture type. Instead, our goal was to describe the natural history of patients initially treated nonoperatively for a distal radius fracture to help guide patient and physician counseling. Lastly, we chose to define our cohort as 55 years and older based upon inclusion criteria supporting nonoperative treatment of displaced distal radius factures along with the CPG at time of data collection and with the goal of including a broad cohort to evaluate difference in age that would be less informative with only a greater than 65 cohort.

Despite these limitations, we report a low rate of "older" patients undergoing malunion correction within 1 year after being treated nonoperatively for distal radius fractures. Our results demonstrate that younger and healthier patients in the cohort are those subsequently indicated for malunion correction, whether this is due to perception of functional limitations, being offered subsequent surgery based on age, or both is unknown based on our results. We also demonstrate geographical variation in treatment patterns unlikely to be explained by patient-level factors (e.g., preference). These results highlight potential opportunities for further characterization of operative and nonoperative treatment of distal radius fractures in "older" patients and can inform patient counseling for distal radius fracture treatment in the "older" population.

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Conflict of Interest
Two authors (M.J.R., D.S.R.) have conflicts of interest outside of this submitted work; no benefits were received related directly or indirectly to the subject of this article. Aside from that noted above, no other authors received or will receive benefits in any form related directly or indirectly to the subject of this article.

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